Remarks/Arguments

Applicants hereby request further examination of the subject application in view of the amendments, remarks, RCE and 1 month extension presented herein.

Claim Rejections – 35 USC § 103

Claim 1 is rejected under 35 USC § 103(a) as being unpatentable over Gittleman et al. (US 6,694,692). Applicants respectfully traverse the rejection.

Applicants have amended the transitional phrase of Claim 1 from "comprising" to "consisting of" thereby closing the claim to any element not specified in the claim, specifically establishing the absence of a gas shift reactor element. Applicants have also canceled Claim 7 and incorporated the recycle claim element into Claim 1 further distinguishing the invention from prior art.

Gittleman's apparatus comprises a "non-rotating shift reactor **2**" adapted to receive a gas stream of H_2 and CO from an upstream reactor **1** (Claims 1, 19 & Figure 1). In contrast, the applicants' apparatus consists of a fuel reformer **11** (¶ [0017] & Claim 1) as a functional equivalent to Gittleman's upstream reactor **1** and non-rotating shift reactor **2** combined. Gittleman teaches that in the catalytic non-rotating shift reactor **2**, "carbon monoxide and water are converted to hydrogen and carbon dioxide via the water gas shift reaction" (col. 3, lines 44-46). The applicants teach that the shift reactor is not necessary and, instead, this chemical reaction is done in the fuel reformer **11** yielding a product enriched in CO and H_2. (¶ [0017]).

Further, Gittleman teaches that "the water gas shift reactor **2** may contain either high or low temperature water gas shift catalysts, or both, depending on the nature of the reactor" (col. 3, lines 57-62). The applicants' invention teaches away from Gittleman by not having a gas shift reactor or a gas shift catalyst. Stated another way, Gittleman's system will not function without the shift reactor whereas the applicants' system is specifically designed to function without the shift reactor. Gittleman's shift reactor **2** is designed to effect a catalytic chemical reaction in which CO reacts with hydrocarbons and/or water to form additional (to that formed in his primary reactor **1**) H_2 and CO_2. Whereas, the applicants' invention teaches away from Gittleman in that the product from the reformer **11** is cooled in heat exchanger **12** and then passed into a

scrubber **13** in which all gases except hydrogen are adsorbed and the hydrogen passes through to the fuel cell **14** inlet. CO and/or methane are recycled from the scrubber **13** to the reformer **11** to enhance system efficiency.

Additionally, the applicants' adsorbent scrubber **13** involves only physical adsorption and desorption, i.e., no chemical processes, as described in paragraph [0015] and the listed patents incorporated by reference. On desorption, the desorbed gases are recycled to the reformer **11** for further reaction and conversion of the balance of CO and methane, CH_4, to H_2 and CO_2.

Additionally, applicants paragraph [0015] and Figure 2 teaches, "… CO and/or methane can be recycled from the scrubber **13** to the reformer **11** to further improve cycle efficiency." Gittleman has no teaching or suggestion of a recycle loop to improve the efficiency of the reactions.

The rejection is overcome, and applicant respectfully requests withdrawal thereof.

Claims 2-3 are rejected under 35 USC § 103(a) as being unpatentable over Gittleman (US 6,964,692) in view of Hayes (5,709,914). Applicants respectfully traverse the rejection.

The combination of Gittleman and Hayes teaches a "non-rotating shift reactor **2**" adapted to receive a gas stream of H_2 and CO from an upstream reactor **1** (Claims 1, 19 & Figure 1). In contrast, the applicants' apparatus consists of a fuel reformer **11** (¶ [0017] & Claim 1) as a functional equivalent to Gittleman's upstream reactor **1** and non-rotating shift reactor **2** combined. Gittleman teaches that in the catalytic non-rotating shift reactor **2**, "carbon monoxide and water are converted to hydrogen and carbon dioxide via the water gas shift reaction" (col. 3, lines 44-46). The applicants teach that the shift reactor is not necessary and, instead, this chemical reaction is done in the fuel reformer **11** yielding a product enriched in CO and H_2. (¶ [0017]).

Further, the combination of Gittleman and Hayes teaches that "the water gas shift reactor **2** may contain either high or low temperature water gas shift catalysts, or both, depending on the nature of the reactor" (col. 3, lines 57-62). The applicants' invention teaches away from the Gittleman/Hayes combination by not having a gas shift reactor or a gas shift catalyst. Stated

another way, Gittleman/Hayes's system will not function without the shift reactor whereas the applicants' system is specifically designed to function without the shift reactor. Gittleman/Hayes's shift reactor **2** is designed to effect a catalytic chemical reaction in which CO reacts with hydrocarbons and/or water to form additional (to that formed in his primary reactor **1**) H_2 and CO_2. Whereas, the applicants' invention teaches away from Gittleman/Hayes in that the product from the reformer **11** is cooled in heat exchanger **12** and then passed into a scrubber **13** in which all gases except hydrogen are adsorbed and the hydrogen passes through to the fuel cell **14** inlet. CO and/or methane are recycled from the scrubber **13** to the reformer **11** to enhance system efficiency.

Additionally, the applicants' adsorbent scrubber **13** involves only physical adsorption and desorption, i.e., no chemical processes, as described in paragraph [0015] and the listed patents incorporated by reference. On desorption, the desorbed gases are recycled to the reformer **11** for further reaction and conversion of the balance of CO and methane, CH_4, to H_2 and CO_2.

Additionally, applicants paragraph [0015] and Figure 2 teaches, "... CO and/or methane can be recycled from the scrubber **13** to the reformer **11** to further improve cycle efficiency." Gittleman has no teaching or suggestion of a recycle loop to improve the efficiency of the reactions.

Regarding the heat exchanger, the examiner acknowledges that Gittleman does not prescribe a carbon foam heat exchanger. Gittleman teaches that his heat exchanger (6) is used to heat a steam/compressed air stream (15) by cooling the effluent stream (12) from his primary reactor (1) [col. 3, line 13-16]. Gittleman further teaches that his water gas shift reactor (2) may be a high temperature (320-500°C), medium temperature (250-400°C) or low temperature (150-250°C) shift reactor [col. 3, line 37-40]. Thus, Gittleman's heat exchanger will cool stream (12) only as low as 150°C. In contrast, the applicants' heat exchanger (12) is a graphitic carbon foam heat exchanger or radiant cooler [¶ [0016] & [0017]], which is used to cool the effluent stream from heat exchanger (12) to ambient temperature, i.e., 25-35°C, which is the preferred operating temperature of the CFCMS scrubber (13). The applicants' heat exchanger (12) would cool Gittleman's stream (12) to below his minimum temperature of 150°C, or alternatively, his heat exchanger (6) would not cool the applicants' stream to 25-35°C.

The rejection is overcome, and applicant respectfully requests withdrawal thereof.

Claim 4 is rejected under 35 USC § 103(a) as being unpatentable over Gittleman (US 6,964,692) in view of Wilson (US 5,827,355). Applicants respectfully traverse the rejection.

The combination of Gittleman and Wilson teaches a "non-rotating shift reactor **2**" adapted to receive a gas stream of H_2 and CO from an upstream reactor **1** (Claims 1, 19 & Figure 1). In contrast, the applicants' apparatus consists of a fuel reformer **11** (¶ [0017] & Claim 1) as a functional equivalent to Gittleman's upstream reactor **1** and non-rotating shift reactor **2** combined. Gittleman teaches that in the catalytic non-rotating shift reactor **2**, "carbon monoxide and water are converted to hydrogen and carbon dioxide via the water gas shift reaction" (col. 3, lines 44-46). The applicants teach that the shift reactor is not necessary and, instead, this chemical reaction is done in the fuel reformer **11** yielding a product enriched in CO and H_2. (¶ [0017]).

Further, the combination of Gittleman and Wilson teaches that "the water gas shift reactor **2** may contain either high or low temperature water gas shift catalysts, or both, depending on the nature of the reactor" (col. 3, lines 57-62). The applicants' invention teaches away from the Gittleman/Wilson combination by not having a gas shift reactor or a gas shift catalyst. Stated another way, Gittleman/Wilson's system will not function without the shift reactor whereas the applicants' system is specifically designed to function without the shift reactor. Gittleman/Wilson's shift reactor **2** is designed to effect a catalytic chemical reaction in which CO reacts with hydrocarbons and/or water to form additional (to that formed in his primary reactor **1**) H_2 and CO_2. Whereas, the applicants' invention teaches away from Gittleman/Wilson in that the product from the reformer **11** is cooled in heat exchanger **12** and then passed into a scrubber **13** in which all gases except hydrogen are adsorbed and the hydrogen passes through to the fuel cell **14** inlet. CO and/or methane are recycled from the scrubber **13** to the reformer **11** to enhance system efficiency.

Additionally, the applicants' adsorbent scrubber **13** involves only physical adsorption and desorption, i.e., no chemical processes, as described in paragraph [0015] and the listed patents incorporated by reference. On desorption, the desorbed gases are recycled to the reformer **11** for further reaction and conversion of the balance of CO and methane, CH_4, to H_2 and CO_2.

Additionally, applicants paragraph [0015] and Figure 2 teaches, "… CO and/or methane can be recycled from the scrubber **13** to the reformer **11** to further improve cycle efficiency." Gittleman/Wilson has no teaching or suggestion of a recycle loop to improve the efficiency of the reactions.

Regarding the scrubber, Gittleman teaches the use of chemisorbers consisting of: oxides or salts of copper, silver, or tin impregnated or exchanged on activated carbon, alumina, and zeolites, and mixtures thereof [col. 3, line 60-62 & Claim 10]. The applicants' invention teaches the use of a physical adsorbent only. One of the practical implications of this is the difference in operating temperatures of these respective adsorbers. Gittleman teaches an adsorber operating temperature of 60-100 °C. The CFCMS has an operating temperature of 25-35 °C.

The rejection is overcome, and applicant respectfully requests withdrawal thereof.

Claim 7 is rejected under 35 USC § 103(a) as being unpatentable over Gittleman (US 6,964,692) in view of Asou (US 2002/0150800). Applicants have canceled Claim 7 thereby overcoming the rejection.

The applicants' review of the Gittleman/Asou combination found the following distinctions. Asou teaches "…the resultant shifted gas flows out of the shifting unit 4 and into a purifying unit 5 filled with a CO removing (purifying) catalyst to be purified…." [¶ [0038]] Thus, Asou teaches a catalytic chemical process in purifying unit 5 whereas the applicants' invention teaches only physical processes for the purification/scrubbing of a gas to recycle it to the reforming reactor. Further, Asou teaches that the purified gas is, in part, directed to a burner 8 [¶ [0038]]. This teaches away from the applicants' invention in that the applicants recycle to the reforming reactor. Further, Asou does not cool the gas between the shifting unit 4, which yields a gas at 400 °C, and the purifying unit 5. Further, Asou does not teach a "scrubber", but instead teaches a purifying unit 5 which is not a scrubber, even though the examiner refers to the device as a carbon monoxide scrubber/purifying unit.

The rejection is overcome, and applicant respectfully requests withdrawal thereof.

Applicants confirm that no new matter is introduced with these amendments. In view of the above amendments and remarks, it is submitted that the Examiner's rejections are overcome, and that applicant's claims are in condition for allowance. Applicants therefore earnestly solicit allowance thereof, and the issue of U.S. letters patent therefore.

Respectfully submitted:

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